(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 417 320 A1**

# (12) EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC

(21) Application number: **90905630.1**

(22) Date of filing: **30.03.90**

(86) International application number: **PCT/JP90/00439**

(87) International publication number: **WO 90/11872 (18.10.90 90/24)**

(51) Int. Cl.[5]: **B25J 9/10**, B25J 9/22, G05B 19/18

(30) Priority: **31.03.89 JP 78393/89**

(43) Date of publication of application: **20.03.91 Bulletin 91/12**

(84) Designated Contracting States: **DE FR GB**

(71) Applicant: **FANUC LTD.**
**3580, Shibokusa Aza-Komanba, Oshino-mura**
**Minamitsuru-gun, Yamanashi 401-05(JP)**

(72) Inventor: **HARA, Ryuichi Room 7-206, Fanuc Manshonharimomi**
**3539-1, Shibokusa Oshino-mura**
**Minamitsuru-gun**
**Yamanashi 401-05(JP)**

(74) Representative: **Billington, Lawrence Emlyn**
**Haseltine Lake & Co Hazlitt House 28, Southampton Buildings Chancery Lane**
**London WC2A 1AT(GB)**

## (54) METHOD FOR SETTING TOOL CENTER POINT FOR ROBOT.

(57) This invention relates to a method for setting tool center point for a robot that makes the setting of a tool center point possible accurately and simply without removing a tool from the robot. After a tool (50) is mounted to a tool mounting face (34), a tool center point (51) is set at the center (35) of the tool mounting face by a robot control device, and the robot is manually operated to position the tool center point at a reference point (61), teaching the state of this positioning. A matrix **P1** is determined by the robot control device based on the teaching data. Next,the tool center point is set at a setting point (36) and the setting point is positioned at the reference point by manual operation of the robot, teaching the state of this positioning. A matrix **P2'** is determined by the teaching data, and a transformation matrix **TCP** from a tool mounting face coordinates system (200) to a tool coordinates system (300) is further determined in accordance with an equation **TCP** = $\mathbf{P1}^{-1}.\mathbf{P2'}$. Or, a matrix **P2** that shows the positioning state of the setting point at the reference point with the tool center point set at the center of the tool mounting face is determined, than the transforming matrix is determined in accordance with an equation **TCP** = $\mathbf{P1}^{-1}.\mathbf{P2}.\mathbf{X}$ using a matrix X showing the position and the attitude of the setting point in the tool mounting face coordinates system.

EP 0 417 320 A1

# TOOL CENTER POINT SETTING METHOD IN A ROBOT

## Technical Field

The present invention relates to a tool center point setting method in a robot, and more particularly, to a method capable of accurately and easily setting the tool center point without the need of removing a tool from a robot.

## Background Art

Generally, during a robot operation, the target position and orientation of a robot tool, which are stated in a program created beforehand on an off-line basis and are represented by an orthogonal coordinate system, are converted into target values of joint angles of individual axes of the robot, and the joint angles are respectively controlled to these target joint angles. In this coordinate system conversion, various transformation matrices are used for the coordinate conversion between adjacent ones of various coordinate systems set for various sections of the robot. For example, employed is a transformation matrix for the coordinate conversion from a coordinate system set for the tool mounting surface into a tool coordinate system.

Conventionally, to determine the transformation matrix (i.e., to set the tool center point), at first, the distal end of a tool mounted to the tool mounting surface is positioned at a reference point whose coordinate position in a reference coordinate system is unknown, and a matrix **P1"** representing the position and orientation of the center of the tool mounting surface in the reference coordinate system at that time is derived. Then, after the tool is removed from the tool mounting surface, the center of the tool mounting surface is brought to the reference position, and a matrix **P2"** representing the position and orientation of the center of the tool mounting surface in the reference coordinate system at that time is derived. Assuming here that the transformation matrix is **TCP"** and an unknown matrix representing the coordinate position of the reference point in the reference coordinate system is **P0"**, then the relationships represented by the following equations (1) and (2) stand between the matrices **P0"**, **P1"** and **TCP"** and between the matrices **P0"** and **P2"**, respectively. By eliminating the unknown matrix **P0"** from equation (1) using equation (2), the following equation (3) is derived. In equation (3), symbol $\mathbf{P1}''^{-1}$ represents the inverse matrix of the matrix **P1"**. In this manner, according to the conventional method, the transformation matrix **TCP"** is derived in accordance with equation (3).

$$P1'' \cdot TCP'' = P0'' \qquad \ldots (1)$$

$$P2'' = P0'' \qquad \ldots (2)$$

$$TCP'' = P1''^{-1} \cdot P2'' \qquad \ldots (3)$$

In an actual working site, however, it is sometimes impossible to remove the tool from the tool mounting surface. In such a case, the conventional method cannot be used because it requires that the tool be removed to permit the center of the tool mounting surface to be positioned at the reference point.

Another tool center point setting method which does not require the removal of a tool is also known in the art. According to the method proposed in Japanese Patent Application No. 62-229820, for example, the operation of determining the center of the tool mounting surface while holding the distal end of the tool mounted to the tool mounting surface at the reference point is carried out with respect to at least four different orientations of the robot while the robot orientation is being changed. Then, the position of the tool center point is determined on the basis of the coordinate position of the center of a sphere passing the at least four tool mounting surface centers thus determined.

According to this conventional method, however, in order to determine the position of the tool center point with a required accuracy, the operation of positioning the distal end of the tool at the reference point while the robot orientation is being changed must be repeatedly carried out a large number of times. This requires much labor. Moreover, the orientation of the tool cannot be determined.

## Disclosure of the Invention

An object of the present invention is to provide a method which is capable of accurately and easily setting the tool center point of a robot without the need of removing the tool from the robot.

To achieve the above object, according to one aspect of the present invention, there is provided a tool center point setting method which comprises the steps of: (a) providing in a robot a set point whose position and direction relative to a center of a tool mounting surface are known; (b) providing a reference point in a robot installation space; (c) setting a tool center point at the center of the tool mounting surface, positioning the tool center point at the reference point, and teaching first position and orientation of the tool center point at that time; (d) setting the tool center point at the set point, positioning the set point at the reference point, and teaching second position and orientation of the tool center point at that time; and (e) deriving a transformation matrix on the basis of an inverse matrix of a matrix representing the first position and orientation, and a matrix representing the second position and orientation.

According to another aspect of the present invention, there is provided a tool center point setting method comprising the steps of: (a) providing in a robot a set point whose position and direction relative to a center of a tool mounting surface are known; (b) providing a reference point in a robot installation space; (c) setting a tool center point at the center of the tool mounting surface, positioning the tool center point at the reference point, and teaching first position and orientation of the tool center point at that time; (d) positioning the set point at the reference point with the tool center point kept set at the center of the tool mounting surface, and teaching second position and orientation of the tool center point at that time; and (e) deriving a transformation matrix on the basis of an inverse matrix of a matrix representing the first position and orientation, a matrix representing the second position and orientation, and a matrix representing position and orientation of the set point in a coordinate system set for the tool mounting surface.

As described above, according to the present invention, the transformation matrix including a tool orientation, i.e., the tool center point, can be accurately and easily set by merely teaching the tool center point assumed when the tool center point is positioned sequentlally at the reference point and the set point, or when the tool center polnt is set at the reference point and then the set point is positioned at the reference point. Accordingly, the robot operating performance such as tool path accuracy can be improved.

## Brief Description of the Drawings

Fig. 1 is a schematic block diagram showing a robot to which a tool center point setting method according to a first embodiment of the present invention is applied;

Fig. 2 is a schematic perspective view of a robot mechanism of Fig. 1 in a state wherein the distal end of a tool is positioned at a reference point (the distal end of a jig);

Fig. 3 is a schematic perspective view of the robot mechanism in a state in which a set point is positioned at the reference point;

Fig. 4 is a flowchart of a tool center point setting process executed by a robot control unit of Fig. 1; and

Fig. 5 is a flowchart, similar to Fig. 4, showing a setting method according to a second embodiment of the present invention.

## Best Mode of Carrying Out the Invention

Referring to Fig. 1, a robot for embodying a tool center point setting method of a first embodiment of the present invention comprises a control unit 20, and a robot mechanism 30 for performing operations for a work object 40 under the control of the control unit 20. As shown in Figs. 2 and 3, the robot mechanism 30 includes an arm 31 composed of a plurality of links (not shown) interconnected by means of joints (not shown), a wrist portion 32 mounted to the distal end of the arm, and servomotors (not shown) for individual axes. The wrist portion 32 includes a flange 33 secured at a distal end thereof, and a tool 50 is mounted to the distal end face (tool mounting surface) 34 of the flange 33. Reference numeral 51 denotes the distal end of the tool as the tool center point.

The control unit 20 is arranged to perform a coordinate conversion process, using various transformation matrices, on the target position and orientation of the tool 50, which are stated in a program created beforehand on an off-line basis and are represented by an orthogonal coordinate system, thereby deriving target joint angles of respective axes of the robot, and is arranged to drive the servomotors of the individual axes of the robot mechanism 30 in accordance with these target joint angles, to thereby control the position and orientation of the tool 50. The robot mechanism 30 also includes various sensors (not shown) for detecting rotation angles (joint angles of the respective axes) of the servomotors for the individual axes.

A set point 36 (indicated by triangle mark in Figs. 2 and 3) is set at a predetermined portion of the robot mechanism 30, for example, at a predetermined position on the outer peripheral edge of the tool mounting surface 34. The direction of the set point 36 relative to the center 35 of the tool mounting surface and a distance between the set point and the center 35 (the position and orientation thereof in the coordinate system set for the tool mounting surface, described later) are known. Moreover, the set point 36 is set at such a portion that the set point can be positioned at the distal end 61 of a positioning jig 60, with the tool 50 kept mounted to the tool mounting surface 34. In a robot installation space, the jig 60 may be provided at an arbitrary position on a robot installation floor 70, for instance. In this respect, the jig has its distal end (reference point ) 61 whose coordinate position in the reference coordinate system 100 may be unknown. In Fig. 3, reference numerals 200 and 300 denote the coordinate system for the tool mounting surface and the tool coordinate system, respectively. These coordinate systems are set such that their coordinate origins respectively coincide with the center 35 of the tool mounting surface and the center of the distal end 5l of the tool, for example.

Referring again to Fig. 1, the control unit 20 includes a central processing unit (hereinafter referred to as CPU) 21, a read-only memory (ROM) 22 storing a control program, and a random-access memory (RAM) 23 for storing various data including teaching data, various calculation results derived by the CPU 21, etc. The control unit 20 further comprises a teaching pendant 24 including a teaching key (not shown) for teaching the robot, a manual data input unit (hereinafter referred to as a CRT/MDI) 25 with a display, an axis controller 26, and an interface 28, and is arranged to drivingly control the servomotors of the individual axes of the robot mechanism 30. The aforementioned elements 22 to 26 and 28 are connected to the CPU 21 via a bus 29, and various sensors (not shown) provided on the robot mechanism 30 and the work object 40 are connected to the interface 28.

With reference to Figs. 1 to 4, the tool center point setting process executed by the robot constructed as mentioned above will be explained.

After the tool 50 is mounted to the tool mounting surface 34 of the robot, an operator operates the CRT/MDI 25 to set the operation mode of the control unit 20 in a tool center point setting mode. At this time, a transformation matrix **TCP** (in this embodiment, each of the transformation matrix **TCP** and various matrices mentioned later is constituted by a homogeneous transformation matrix of 4x4) from the tool mounting surface coordinate system 200 to the tool coordinate system 300, employed for the aforementioned coordinate conversion process, is provisionally set to a 4 X 4 unit matrix determined beforehand as a default value. Then, the same transformation matrix is stored in a predetermined address area of the RAM 23. In other words, the tool coordinate system 300 is brought into coincidence with the tool mounting surface coordinate system 200. Namely, the tool center point (in this embodiment, the distal end 51 of the tool) is set at the center 35 of the tool mounting surface.

During a robot operation in the tool center point setting mode, a first message "POSITION TOOL CENTER POINT AT REFERENCE POINT" is displayed on the CRT screen of the CRT/MDI 25 under the control of the CPU 21 of the control unit 20 (step S1), and the CPU 21 waits for an operation of the teaching key by the operator. In response to the first message, the operator operates the teaching pendant 24 to manually drive the robot so that the distal end 51 of the tool (tool center point) is brought to be coincident with the distal end of the jig, I.e., the reference point (Fig. 2), and then turns on the teaching key. When it is determined in step S2 that the teaching key has been turned on, the CPU 21 determines a matrix **P1** representing the position and orientation (first position) of the distal end 51 of the tool in the reference coordinate system in the thus positioned state, on the basis of the joint angles of the respective axes of the robot at that time and the transformation matrix **TCP** (the aforesaid unit matrix) at that time. This matrix **P1** is stored in a predetermined address area of the RAM 23 (step S3). Here, assuming that an unknown matrix representing the coordinate position of the reference point 61 in the reference coordinate system 100 is **P0**, then the following equation (4) is fulfilled.

$$\mathrm{P1} \cdot \mathrm{TCP} = \mathrm{P0} \qquad \ldots \quad (4)$$

Next, in place of the unit matrix, the CPU 21 provisionally sets, as the transformation matrix **TCP**, a matrix X which is previously set and represents the position and orientation of the set point 36 in the tool mounting surface coordinate system 200 (step S4). In other words, the tool center point (the distal end of the tool) 51 is set at the set point 36. Then, the CPU 21 causes the CRT/MDI 25 to display a second message "POSITION SETTING POINT AT REFERENCE POINT" (step S5), and waits for an operation of the teaching key. In response to the second message, the operator manually operates the robot to bring the set point 36 to be coincident with the distal end 61 of the jig (Fig. 3), and then turns on the teaching key.

When this key operation is detected (step S6), the CPU 21 determines a matrix **P2'** representing the position and orientation (second position) of the distal end 51 of the tool in the reference coordinate system in the thus positioned state, on the basis of the joint angles of the individual axes at that time and the transformation matrix **TCP** (here, the aforesaid matrix X) at that time. Then, the matrix **P2'** is stored in the RAM 23 (step S7). In this case, the following equation (5) is fulfilled.

$$\mathbf{P2'} = \mathbf{P2} \cdot \mathbf{X} = \mathbf{P0} \qquad \ldots (5)$$

where symbol **P2** denotes a matrix used in a second embodiment described later.

Then, the CPU 21 determines the transformation matrix **TCP** in accordance with the following equation (6), derived from equations (4) and (5) and not including the unknown matrix **P0**, and causes the RAM 23 to store the matrix thus determined. Namely, the tool center point is set.

$$\mathbf{TCP} = \mathbf{P1}^{-1} \cdot \mathbf{P2'} \qquad \ldots (6)$$

where matrix $\mathbf{P1}^{-1}$ is the inverse matrix of the matrix **P1**.

During an actual robot operation to perform work onto the work object 40, the control unit 20 converts the target position and orientation of the tool 50 expressed in the orthogonal coordinate system into target joint angles of the respective axes, using various transformation matrices including the transformation matrix **TCP**, and controls the robot mechanism 30 in accordance with the conversion results.

Next, a tool center point setting method according to a second embodiment of the present invention will be explained.

The second embodiment is similar to the first embodiment in that it can be carried out by the robot shown in Figs. 1 to 3 but different therefrom in that the transformation matrix **TCP** is derived in accordance with the below-mentioned equation (8) different from equation (6).

With reference to Fig. 5, a tool center point setting process according to the second embodiment will be described.

When the tool center point setting mode is set, steps S11 to S13 corresponding to steps S1 to S3 in the first embodiment are executed. That is, the tool center point is set at the center of the tool mounting surface and the first message is displayed, and then the matrix **P1** representing the first position is determined in accordance with the key operation effected after the tool center point is positioned at the reference point. In this case, the aforementioned equation (4) is fulfilled.

Then, unlike the first embodiment, the CPU 21 causes the second message to be displayed (step S14), without carrying out the setting (step S4) of the tool center point (the distal end of the tool) 51 at the set point 36, that is, with the tool center point kept positioned at the center 35 of the tool mounting surface. Then, when the teaching key is turned on (step S15) after the robot is manually operated in response to the second message so that the set point 36 is positioned at the distal end of the jig (reference point) 61, the CPU 21 determines the matrix **P2** representing the position and orientation (second position) of the tool center point 51 in the reference coordinate system in the thus positioned state, on the basis of the joint angles of the respective axes at that time and the aforesaid unit matrix, and causes the RAM 23 to store the matrix **P2**. At this time, the following equation (7) is fulfilled.

$$\mathbf{P2} \cdot \mathbf{X} = \mathbf{P0} \qquad \ldots (7)$$

Next, the CPU 21 determines the transformation matrix **TCP** in accordance with the following equation (8) derived from equations (4) and (7). Namely, the tool center point is set.

$$\mathbf{TCP} = \mathbf{P1}^{-1} \cdot \mathbf{P2} \cdot \mathbf{X} \qquad \ldots (8)$$

This transformation matrix **TCP** is used for the robot control, as in the first embodiment.

The present invention is not limited to the above-described first and second embodiments and various modifications thereof may be made.

For example, in the above embodiments, the conversion from the tool mounting surface coordinate system to the tool coordinate system is represented by the homogeneous transformation matrix **TCP** of 4x4, but an equivalent conversion may alternatively be used. Further, although in the above embodiments,

cases have been explained, wherein the tool point is provided to be coincident with the distal end of the tool, the present invention can be applied to a robot mounted with a tool whose tool point does not coincide with the distal end of the tool. Furthermore, in the above embodiments, the tool coordinate system whose coordinate origin coincides with the tool center point has been explained by way of example, but such setting of the tool coordinate system is not essential to the present invention.

## Claims

1. A tool center point setting method in a robot, comprising the steps of:
   (a) providing in a robot a set point whose position and direction relative to a center of a tool mounting surface are known;
   (b) providing a reference point in a robot installation space;
   (c) setting the tool center point at the center of the tool mounting surface, positioning the tool center point at the reference point, and teaching first position and orientation of the tool center point at that time;
   (d) setting the tool center point at the set point, positioning the set point at the reference point, and teaching second position and orientation of the tool center point at that time; and
   (e) deriving a transformation matrix on the basis of an inverse matrix of a matrix representing the first position and orientation, and a matrix representing the second position and orientation.

2. A tool center point setting method according to claim 1, wherein said matrices representing the first position and orientation and the second position and orientation, respectively, are determined on the basis of joint angles of individual axes of the robot assumed at the time of teaching operations in said steps (c) and (d), respectively.

3. A tool center point setting method according to claim 1, wherein said set point is provided at a predetermined portion of the robot at which the set point is permitted to be positioned at the reference point with a tool kept mounted to the robot.

4. A tool center point setting method according to claim 1, wherein a coordinate position of the reference point in a reference coordinate system is unknown.

5. A tool center point setting method according to claim 1, wherein said setting of the tool center point at the center of the tool mounting surface is carried out by provisionally setting the transformation matrix to a unit matrix.

6. A tool center point setting method according to claim 1, wherein said setting of the tool center point at the set point is carried out by provisionally setting the transformation matrix to a matrix representing position and orientation of the set point in a coordinate system set for the tool mounting surface.

7. A tool center point setting method according to claim 1, wherein said tool center point is a distal end of a tool.

8. A tool center point setting method in a robot, comprising the steps of:
   (a) providing in a robot a set point whose position and direction relative to a center of a tool mounting surface are known;
   (b) providing a reference point in a robot installation space;
   (c) setting a tool center point at the center of the tool mounting surface, positioning the tool center point at the reference point, and teaching first position and orientation of the tool center point at that time;
   (d) positioning the set point at the reference point with the tool center point kept set at the center of the tool mounting surface, and teaching second position and orientation of the tool center point at that time; and
   (e) deriving a transformation matrix on the basis of an inverse matrix of a matrix representing the first position and orientation, a matrix representing the second position and orientation, and a matrix representing position and orientation of the set point in a coordinate system set for the tool mounting surface.

9. A tool center point setting method according to claim 8, wherein said matrices representing the first position and orientation and the second posltion and orientation, respectively, are determined on the basis of joint angles of individual axes of the robot assumed at the time of teaching operations in said steps (c) and (d), respectively.

10. A tool center point setting method according to claim 8, wherein said set point is provided at a predetermined portion of a robot at which the set point is permitted to be positioned at the reference point with a tool kept mounted to the robot.

11. A tool center point setting method according to claim 8, wherein a coordinate position of the reference point in a reference coordinate system is unknown.

12. A tool center point setting method according to claim 8, wherein said setting of the tool center point at the center of the tool mounting surface is carried out by provisionally setting the transformation matrlx to a unit matrix.

13. A tool center point setting method according to claim 8, wherein said tool center point is a distal end of a tool.

FIG.1

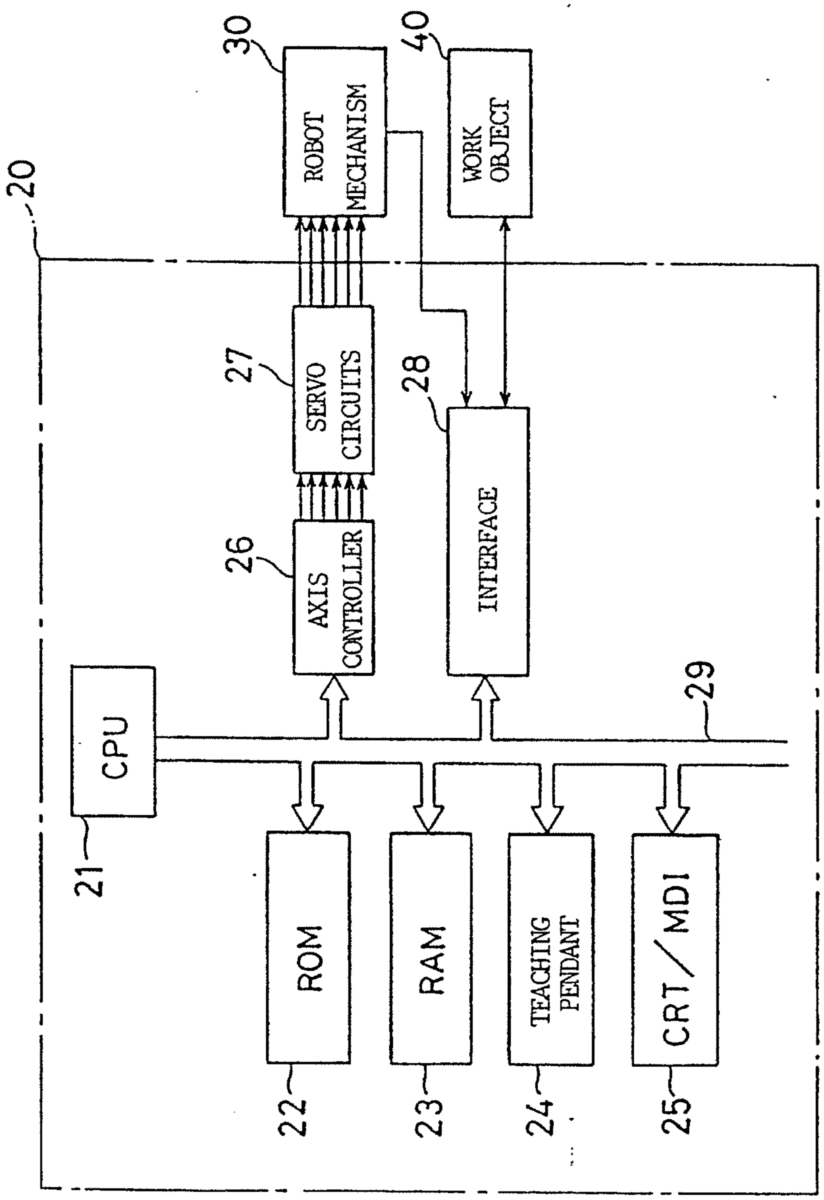

20
CPU
21
ROM
22
RAM
23
TEACHING PENDANT
24
CRT/MDI
25
AXIS CONTROLLER
26
SERVO CIRCUITS
27
INTERFACE
28
29
ROBOT MECHANISM
30
WORK OBJECT
40

FIG.2

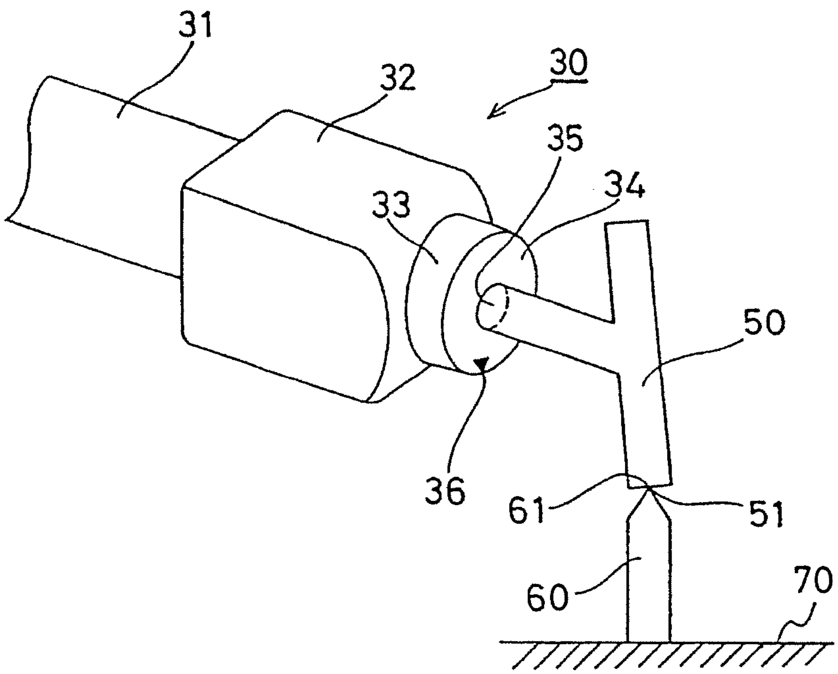



FIG.3

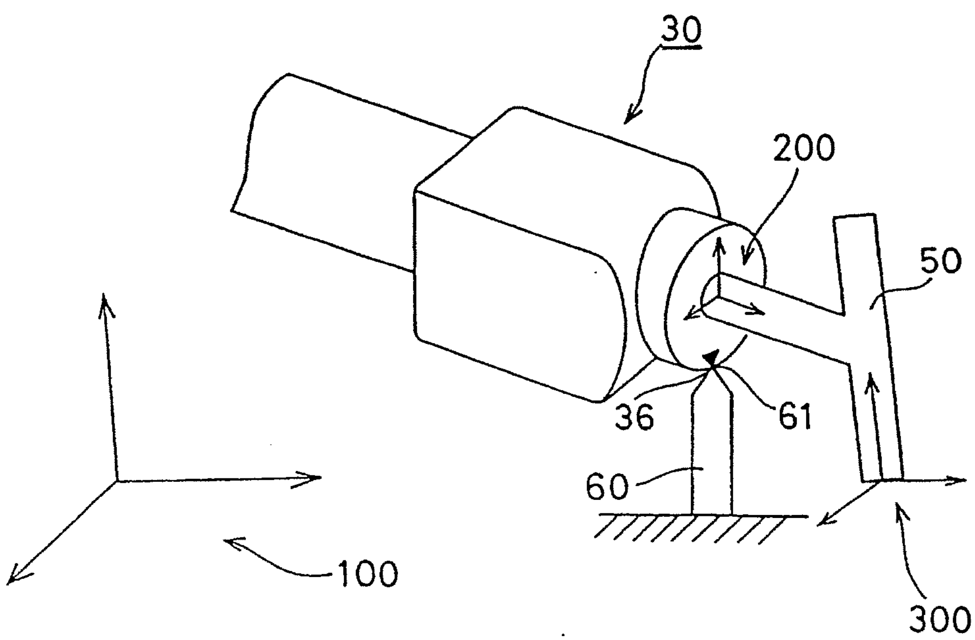


FIG.4

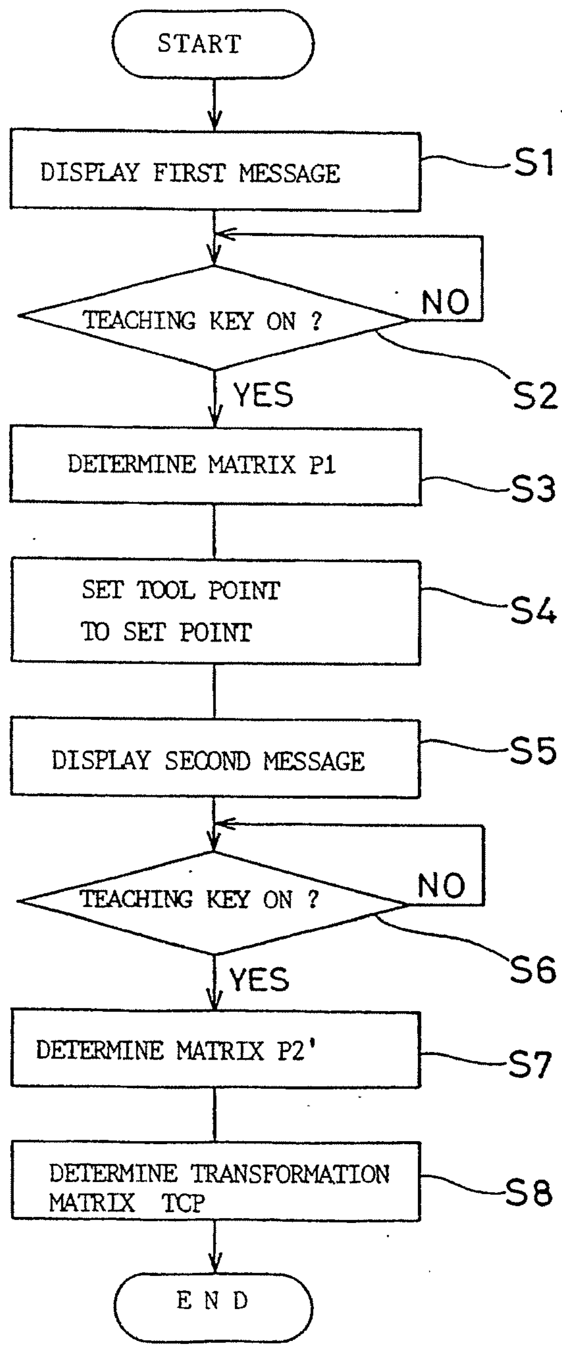
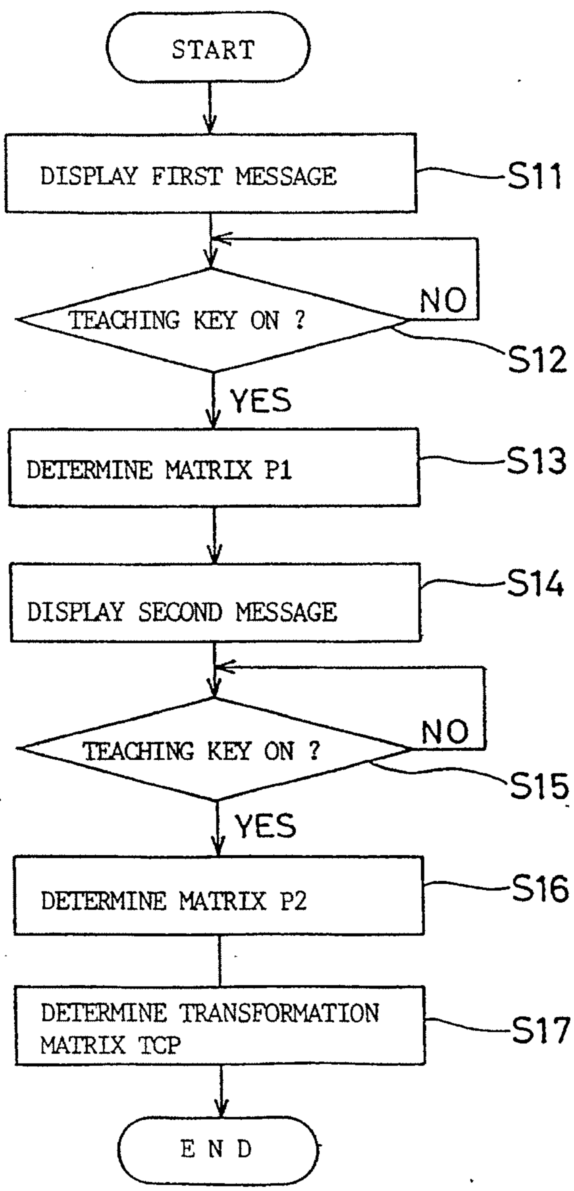

START
DISPLAY FIRST MESSAGE
S1
TEACHING KEY ON ?
NO
YES
S2
DETERMINE MATRIX P1
S3
SET TOOL POINT
TO SET POINT
S4
DISPLAY SECOND MESSAGE
S5
TEACHING KEY ON ?
NO
YES
S6
DETERMINE MATRIX P2'
S7
DETERMINE TRANSFORMATION
MATRIX TCP
S8
E N D

FIG.5


START
DISPLAY FIRST MESSAGE
S11
TEACHING KEY ON ?
NO
S12
YES
DETERMINE MATRIX P1
S13
DISPLAY SECOND MESSAGE
S14
TEACHING KEY ON ?
NO
S15
YES
DETERMINE MATRIX P2
S16
DETERMINE TRANSFORMATION MATRIX TCP
S17
END

# INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/00439

**I. CLASSIFICATION OF SUBJECT MATTER** (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. $Cl^5$ B25J9/10, 9/22, G05B19/18

**II. FIELDS SEARCHED**

Minimum Documentation Searched [7]

| Classification System | Classification Symbols |
|---|---|
| IPC | B25J9/10, 9/22, G05B19/18 |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

| | |
|---|---|
| Jitsuyo Shinan Koho | 1926 - 1989 |
| Kokai Jitsuyo Shinan Koho | 1971 - 1989 |

**III. DOCUMENTS CONSIDERED TO BE RELEVANT** [9]

| Category * | Citation of Document, [11] with indication, where appropriate, of the relevant passages [12] | Relevant to Claim No. [13] |
|---|---|---|
| P,Y | JP, A, 1-234181 (Sanyo Electric Co., Ltd.), 19 September 1989 (19. 09. 89), Line 14, lower left column to lower right column; page 3 (Family: none) | 1, 8 |
| Y | JP, A, 63-229282 (Hitachi, Ltd.), 26 September 1988 (26. 09. 88), Line 17, lower right column, page 2 to line 6, lower left column, page 3 (Family: none) | 1, 8 |
| Y | JP, A, 62-27802 (Fanuc Ltd.), 5 February 1987 (05. 02. 87), Line 6, lower right column, page 3 to line 5, upper left column, page 4 (Family: none) | 1, 8 |
| Y | JP, A, 61-25207 (Fanuc Ltd.), 4 February 1986 (04. 02. 86), Lines 5 to 14, lower left column, page 1 & WO, A, 8600727 & EP, A, 188623 | 1, 8 |

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

**IV. CERTIFICATION**

| Date of the Actual Completion of the International Search | Date of Mailing of this International Search Report |
|---|---|
| June 18, 1990 (18. 06. 90) | July 2, 1990 (02. 07. 90) |
| **International Searching Authority** | **Signature of Authorized Officer** |
| Japanese Patent Office | |

International Application No. PCT/JP90/00439

**FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET**

| | | |
|---|---|---|
| A | JP, A, 1-257593 (Hitachi, Ltd.), 13 October 1989 (13. 10. 89), (Family: none) | 1, 8 |
| A | JP, A, 1-119806 (Hitachi, Ltd.), 11 May 1989 (11. 05. 89), (Family: none) | 1, 8 |
| A | JP, A, 64-78774 (Fanuc Ltd.), 24 March 1989 (24. 03. 89), (Family: none) | 1, 8 |
| A | JP, A, 62-43711 (Hitachi, Ltd.), 25 February 1987 (25. 02. 87), (Family: none) | 1, 8 |

**V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]**

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers . because they relate to subject matter not required to be searched by this Authority, namely:

2.☐ Claim numbers . because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.☐ Claim numbers ... ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

**VI.☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]**

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

International Application No. PCT/JP90/00439

**FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET**

| | | |
|---|---|---|
| A | JP, A, 61-294507 (Mitsubishi Electric Corp.), 25 December 1986 (25. 12. 86), (Family: none) | 1, 8 |
| A | JP, A, 61-235909 (Hitachi, Ltd.), 21 October 1986 (21. 10. 86), (Family: none) | 1, 8 |
| A | JP, A, 61-133409 (NACHI-Fujikoshi Corp.), 20 June 1986 (20. 06. 86), (Family: none) | 1, 8 |

**V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]**

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers , because they relate to subject metter not required to be searched by this Authority, namely:

2.☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.☐ Claim numbers , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

**VI.☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]**

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this International search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this International search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET**

| | | |
|---|---|---|
| A | JP, A, 60-209806 (Fanuc Ltd.), 22 October 1985 (22. 10. 85), (Family: none) | 1, 8 |
| A | JP, A, 60-25681 (International Business Machines Corp.), 8 February 1985 (08. 02. 85) & DK, A, 357684 & NO, A, 842908 & SE, A, 8304101 & EP, A, 132616 | 1, 8 |

**V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]**

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ... . because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers ........, because they relete to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers ........, because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

**VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]**

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.